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Public Health Service • Environmental Health Service

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭl'o
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

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In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and x rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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Department of the Interior
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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Environmental Health Service ● Bureau of Radiological Health

Technical Note

Environmental Surveillance Around Nuclear Power Reactors

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Experience gained over the past several years by the Bureau of Radiological Health and by various States has provided a technical basis for the establishment of surveillance programs in the environs of nuclear plants. The guidance for environmental surveillance of nuclear facilities provided by the Bureau of Radiological Health for use by States is applicable to those areas external to the facility's site perimeter or fenced area, which are normally considered as the plant environs or offsite area. Accomplishment of the objectives of these programs assures the continuing examination and evaluation of the environment needed to insure the continued protection of the health and safety of the public.

The prime objectives of environmental surveillance programs for nuclear power stations are (1) to verify the adequacy of source control, (2) to provide data to estimate population exposure, and (3) to provide a source of data for public information. An environmental surveillance program obviously should be conducted by the facility operator and such a program is required by the Atomic Energy Commission (AEC) license. Some utility companies contract for these programs with commercial laboratories. As a minimum, surveillance activities by the State health agency should provide adequate verification of the facility's data. This procedure allows both the health agency and the operator to have confidence in the accuracy of the results. To assure compatibility of the surveillance data from both Federal and State programs, an Analytical Quality Control Service is available to the States through the Bureau's area laboratories.

The media to be sampled, the frequency of sampling, and the type of analysis needed are all dependent upon the specific objectives that have been established for the surveillance program at the facility by the State and the operator. The extent of surveillance required is dependent on the nuclear facility's location with reference to such factors as population density, meteorology, and other environmental considerations, and the quantities and kinds of radioactive materials discharged. Planning for the environmental surveillance program should include an evaluation of the critical radionuclides anticipated in the normal discharges and the pathways through which they may disperse in the environment and thus expose the population to radiation. Because air and water are pathways through which radioactive contaminants are carried to other segments of the environment, analysis of radioactivity in these media is a basic requirement in the establishment of a surveillance program. Further, an investigation of the site environs is necessary to identify the pathways of exposure and the members of the public most likely to be subjected to potential exposure. Exposure of this critical population group can result from direct external radiation and from intake of radioactive material into the body through ingestion and inhalation.

In initiating an environmental surveillance program (table 1), it is important that radiological measurements be made and data obtained through a preoperational survey of the plant environs. This survey should consider the critical nuclides, pathways, population groups, and any other

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information needed to design the operational program. Additional information and benefits will be obtained for other purposes, such as: (1) a data base to be used in identifying any radioactive material released to the environment by the plant after initial startup, (2) evaluation of the proposed operational surveillance system (3) training and experience for the personnel conducting the survey, and (4) a mechanism for gathering data for public information. Because waste discharges from a nuclear power plant operating under normal conditions may influence radioactivity levels only in a limited area of the environment, preoperational samples should be taken beyond the plant's influence for comparison with those taken near the site. This practice can be continued into the operating phase and a statistical comparison made in order to delineate possible contributions by the plant to environmental radioactivity levels. It has been normal practice for preoperational surveys to be conducted for a period of 1 year before the initial startup of a nuclear installation. In those cases where personnel are inexperienced in surveillance operations and laboratory analysis of samples or special requirements are indicated, a longer period of time may be necessary in order to obtain reliable data for at least 1 year.

The data gathered by the environmental surveillance program during plant operation provides a basis for source control and estimation of population dose. Complete liquid and gaseous radioactivity discharge data should be routinely provided to the health agency by the operator so that the relationship between radioactive discharges and the environmental surveillance data can be established. Experience to date with nuclear power plants has shown that careful waste management and proper operating procedures generally result in radionuclide concentrations in waste effluents less than a few percent of the AEC's licensed discharge limits (*1–3*). It should be noted, however, that the large dilution capacity of condenser cooling water has been a significant factor in achieving these low effluent concentrations. Nuclear plants using cooling towers may not be able to reach such low concentrations because of the reduced volume of water discharged.

Detection of accidental releases from nuclear facilities is not an objective of a routine operational environmental surveillance program. The indication of the need for actions to protect the public or the environment must come from a facility operator immediately following any accidental release based on in-plant conditions and data and not several days or weeks later from routine environmental sampling. For this reason, adequate source monitoring and control must be in effect to detect immediately significant nonroutine releases of radioactivity. In the event of such a release, it is imperative that agencies responsible for public health be promptly notified so that they can initiate measures to protect the public, including emergency monitoring programs to ascertain what protective actions may be required. A special preplanned documented emergency monitoring system is required to provide the mechanism for assessing the public health hazard from an accidental release of radioactivity to the offsite area.

The recommended general program, shown in table 1 which has been published previously (*4, 5*), serves as a guide for the development of an environmental monitoring program, and is, in general, considered adequate from a public health standpoint. However, with the rapid expansion of the nuclear power industry, the number of individual facility monitoring programs will increase. Therefore, the Bureau of Radiological Health is reviewing these surveillance recommendations on the basis of field studies which are being carried out through several of the Bureau's laboratories to obtain information needed to determine whether these recommendations should be modified.

Because of the expansion of the nuclear power industry, it is important to have a coordinated nationwide surveillance program adequate to meet public health responsibilities for estimating population exposure. The Bureau of Radiological Health is proceeding with such a program as part of the Department's overall responsibility for evaluating environmental radiation from all sources. This program is being planned and developed with the cooperation and participation of State health agencies and the AEC. The objective of this effort is to provide a source of published data on environmental radioactivity levels associated with nuclear facilities which is readily available to the public and to the health and scientific community through the Bureau's monthly publication, *Radiological Health Data and Reports*. The implementa-

Table 1. Typical environmental surveillance program for a nuclear power plant

Recommended Surveillance Program			
Vectors or indices	Relative frequency	Analyses	Sampling locations
Surface water: Receiving waters of the facility	Continuous composite or weekly grab	Gross beta and gamma scans. Periodic analysis for ^{3}H with frequency a function of the levels measured	Stream—above and below the facility; reservoir, bay, lake—nearest shoreline; any nearby domestic water suppliers using the receiving waters as a raw water source
Bottom sediments	Semiannually	Gross beta and gamma scans	Near reactor's outfall or above and below the outfall if the receiving water is a stream
Ground water	As applicable (usually quarterly or annually)	Gross beta and gamma scans	Supplies within 5 miles of the facility
Air: a) Inhalation	High-volume samples occasionally Low-volume samples daily or weekly	Gross beta and gamma scans of filters and cartridges	Populated areas within 5–15 miles of the facility
b) Immersion	Dosimeters changed monthly	Integrated dose due to noble gases by appropriate reader device	
Milk	Monthly	Gamma spectrum analysis for ^{131}I	Dairy herds within 10–15 miles of the facility
	Quarterly	^{89}Sr and ^{90}Sr or total Sr by beta analysis	Dairy herds within 10–15 miles of the facility
Aquatic biota	Variable	Gamma spectrum analysis for selected radionuclides	Near the reactor's outfall or above and below if receiving water is a stream
Food crops and other vegetation	Seasonal (before or at harvesting time)	Gamma spectrum analysis	Within a 10–15 mile radius of the facility
Soil	Annually	^{90}Sr and ^{137}Cs or gross beta	Prevailing downwind direction in nearest agricultural areas

tion of this activity will contribute substantially to meeting national objectives of protection of public health and preservation of environmental quality.

Bureau of Radiological Health field studies

The Bureau has conducted several field studies at operating nuclear facilities to obtain radioactivity data on which to base judgments on the surveillance required to better estimate population exposure. These studies have been conducted at a boiling water reactor, a pressurized water reactor, and a fuel reprocessing plant.

The first of these field studies was conducted at the Dresden Nuclear Power Station in Illinois during 1967 and 1968, by the Radiological Engineering Laboratory, Cincinnati, Ohio, in cooperation with the Illinois Department of Public Health, the Atomic Energy Commission, and the Commonwealth Edison Company. This site was selected because of the extensive operating experience with Dresden 1 and the development of other nuclear facilities at the same site. Dresden 1 has been in operation since 1962, and at the time of the study's inception, was the largest (200 MWe) operating boiling water reactor. The specific objectives of the study were to:

1. Develop better data on which to base guidance for environmental surveillance programs,
2. Obtain a more comprehensive knowledge of the problems associated with effluent monitoring from nuclear facilities,
3. Increase the depth of technical knowledge within the Bureau of Radiological Health in order to better assist States in developing surveillance programs, and
4. Evaluate the discharges of liquid and gaseous radioactivity and determine the critical pathways of specific radionuclides from the power plant through the environment to man.

Emphasis was placed on identifying critical pathways of radioactivity from source to man (table 2), including identification of any reconcentration media or indicator radionuclides within the pathways, and correlating stack discharges with the environmental radionuclide levels measured. Since the site will soon contain other reactors and a fuel reprocessing plant, the effect of multiple sources may be investigated at a later date.

Table 2. Sample types analyzed from the Dresden nuclear power station

In-plant	Plant discharges	Environs
Primary coolant	Discharge canal	Plume
Recycled demineralized water	Stack	Milk
Fuel pool water	(A) Gas	Cattle thyroids
Waste neutralizer tank	(B) Particulate filters	Rabbits
Laundry wastes	(C) Charcoal iodine filters	Corn kernels and husks
Delay line (off-gas)		Leafy vegetables
Containment building ventilation filters		Grass
Turbine building ventilation filters		Soil
		Drinking water
		Rain water
		Snow
		River water
		Silt
		Fish
		Deer

Various samples were collected at the Dresden Station for radionuclide analysis: (1) gas and particulates in the reactor discharge lines, (2) liquid wastes at various points within the plant waste systems, and (3) samples taken in the environment. This sampling procedure made it possible to determine the significant radionuclides in the plant before release and to correlate these known quantities discharged with any radionuclides detected in the environment. Critical radionuclides and their pathways through the environment that could cause significant exposure to man were identified. Techniques employed to measure radionuclides during the study were more sensitive than those normally used in routine environmental surveillance programs. This enabled a detailed quantitative evaluation of specific radionuclides to insure that all possible "critical" radionuclides were identified.

The final report for this field study has been published and is available to the public (*6*). The principal conclusions reached in this study can be summarized as follows:

1. The critical pathway for possible exposure of the population from this boiling water reactor was determined to be via the discharge of noble gases to the atmosphere. Based on survey instrument and dosimeter measurements around the site, the annual average whole-body exposure at the sampling locations during the study was estimated to range from 5 to 15 millirems per year. A more precise estimate was difficult because gaseous releases from Dresden resulted in environmental radiation levels which were only marginally above background.

2. Analysis of environmental samples from pathways to man other than the air pathway indicated either no detectable radioactivity as a result of operation of the plant or detectable levels too low to be considered significant in terms of population radiation exposure (table 3).

3. The population dose due to iodine-131 in the gaseous effluent was not measureable; stack discharge levels of iodine were small and this radionuclide was virtually undetectable in the environment.

In order to provide similar data on a pressurized water reactor, a study was conducted at the Yankee Atomic Power Station in Rowe, Mass. This study was just recently completed and the report is now in preparation (*7*). Preliminary data indicate that exposure in the environs from the discharge to the atmosphere of gaseous radioactive wastes from this reactor was not detectable. In addition, sampling of the aquatic environment did not reveal radioactivity levels that would produce measurable exposure to the public.

Table 3. Environmental samples[a]

Date	Radioactivity found in Dresden environs	Concentration
1/18/68	Snow (0.8 km from site in direction of plume)	10 pCi of strontium-89/liter
7/10/68	Cattle thyroids (2.3 km from site)	~0.5 pCi of iodine-131/g
8/20/68	Suspended solids from discharge canal	27 pCi of cobalt-60/g dried silt
		11 pCi of cesium-137/g dried silt
8/21/68	Corn kernels (0.8 km from site)	4.0 pCi of cesium-137/g ash

[a] No radioactivity was found in soil, leafy vegetables, fish, grass, milk, rabbits, deer, drinking water (at Peoria), river water (at Peoria), or rain water, at the Dresden station.

A study by the Northeastern Radiological Health Laboratory is currently under way at the Nuclear Fuel Services, Inc., spent fuel reprocessing plant in western New York State. The objectives of this study are very similar to those discussed above for the nuclear power plants. Publication of the results of this study is planned for 1970.

Liquid waste discharges

Discharges of liquid radioactive wastes from nuclear power plants have been well below the limits specified by the AEC (*3*). A review of reported data has indicated that the type of reactor design (i.e., pressurized water or boiling water reactor) has had no apparent large-scale effect on the quantity or type of liquid wastes discharged to the environment except for tritium which is higher in pressurized water reactors. It is believed that proper in-plant waste management may be the most significant mechanism for the effective minimization of the quantity of radioactive wastes discharged. Thus, there are indications that levels of waste discharges are not necessarily a direct function of power levels.

The principal radionuclides found in liquid waste effluent during the boiling water reactor study, in order of decreasing percentage of 10CFR20 concentration limits, were determined to be iodine-131, strontium–90, strontium–89, cobalt–60, and cesium–137. In establishing a surveillance program for the water environment at an operating boiling water reactor plant, these radionuclides and their pathways to human exposure should be included.

Tritium in the environment

Tritium, a radionuclide resulting from nuclear plant operation, has recently been the focal point of attention. Although tritium is considered to be one of the less hazardous radionuclides, its continued production and release and relatively long radioactive half-life (12.3 years) will lead to increased levels in the environment as the number of nuclear power plants increases. Because tritium is an isotope of hydrogen, it can be metabolized in the form of tritiated water and incorporated into body fluids and tissues, although most of the tritium ingested would pass through the human body fairly rapidly with a biological half-life of about 10–12 days.

The mechanisms for production of tritium in nuclear reactors have been well documented (*8–10*). Data on tritium concentration levels in rivers on which nuclear facilities are located are routinely obtained by the Bureau of Radiological Health and the results periodically reported in *Radiological Health Data and Reports* (*11*). Surveillance of tritium in waters of the United States is now being expanded since the number of nuclear plants is increasing. Tritium concentrations measured in U.S. surface waters during 1967–1968 ranged from 200 to 8,400 pCi/liter. Calculated population exposure rates from continuous ingestion of water containing these concentrations would correspond to 0.03 to 1.4 mrem per year. By comparison the normal average population exposure rate from all natural sources of radioactivity is about 100–125 mrem per year.

The tritium currently found in the environment is largely due to fallout from previous atmospheric testing of nuclear weapons, and the levels are generally decreasing. Calculations made by the Bureau of Radiological Health indicate that tritium discharges from nuclear power plants now operating would have little if any detectable effect on tritium concentrations in the environment. Present tritium discharge levels are only a small fraction of presently accepted maximum permissible concentrations and on this basis do not constitute a significant hazard to public health. However, the anticipated growth of nuclear power with an increase in the number of both power reactors and fuel reprocessing plants will result in increased quantities of tritium being discharged into the environment. This potential source of population exposure will require continued monitoring and evaluation by public health agencies to insure that tritium in the environment does not reach levels of radiological health concern.

Gaseous waste discharges

As in the case of liquid wastes, gaseous discharges from operating nuclear power plants have generally been small fractions of the licensed limits. The principal radionuclides normally discharged, that are of public health interest, are the noble gases. Because of the differences in gaseous waste handling design between boiling

water and pressurized water reactors, there are differences in the radionuclides contained in the effluents from the two kinds of plants. In most of the current boiling water reactor designs, gaseous wastes are discharged continuously following a delay time of approximately 30 minutes. Although relatively high total quantities of gaseous effluents are discharged, they have short half-lives and decay rather substantially before reaching offsite areas. The radionuclides normally contained in a boiling water reactor gaseous effluent would include isotopes of krypton and xenon with krypton–88, xenon–135, xenon–138, and krypton–87 predominating. It should be noted that boiling water reactors planned at three locations are to be equipped with gas holdup capacity which will further reduce offsite exposures. Pressurized water reactor waste treatment system designs incorporate a much longer storage time which allows for radioactive decay and these reactors discharge predominately krypton–85 with some xenon–133, although in very small total quantities. Offsite dose contributions from gaseous discharges have been undetectable in the case of an operating pressurized water reactor and only marginally above background for an operating boiling water reactor for those facilities studied by the Bureau.

Radioactive iodine is also a nuclide of public health concern because of the air-pasture-cow-milk chain which could permit concentration in a child's thyroid. Although it is of concern, these studies and a thorough review of surveillance data have not indicated iodine–131 to be of public health significance as a contaminant from normally operating nuclear power reactors. Iodine–131 was at relatively low concentrations in the gaseous effluent of the boiling water reactor studied and extensive efforts failed to detect this nuclide in environmental milk samples even with analytical techniques more sensitive than those employed in routine surveillance. Pressurized water reactor waste treatment systems normally eliminate iodine–131 through storage and decay because of its short radioactive half-life. During our field study of an operating pressurized water reactor, sampling in the environs failed to detect iodine.

Evaluation of surveillance data

Information from plant operating experience available over the past years has shown that nuclear power plants discharge relatively small quantities of radioactive wastes to the environment. The Bureau of Radiological Health has compiled both discharge and surveillance data obtained by plant operators and by State health agencies. In developing plans for a coordinated national surveillance program, consideration is being given to the publication of this type of data in a uniform manner in *Radiological Health Data and Reports.*

The recent Bureau studies at operating facilities, referred to earlier, confirmed that the discharge of radioactive effluents into the air and water environment has not produced radiation levels at these facilities that would result in radiation doses to the population sufficient to be of public health concern. The Bureau will, however, continue to assess all sources of environmental radiation to determine both short and long-term levels and make estimates of the radiation exposure to man.

The identification of the critical radionuclides and pathways for radionuclides to reach man generally requires that relatively few environmental media be analyzed in order to estimate population exposure from the operation of a nuclear power plant. For this reason, greater emphasis should be placed on conducting the facility environmental surveillance program utilizing a detailed knowledge of the effluent released. Studies have demonstrated that detailed analysis of the plant effluents can be quite meaningful, whereas, it is difficult to detect radioactivity in the environment that has resulted solely from plant operation. Field monitoring of radionuclides outside the plant boundary should be dependent on the level and kind of effluent released, although continuous monitoring of the critical pathway for that particular nuclear plant should be maintained. The use of an integrating dosimeter to measure the exposure resulting from the release of noble gases from a boiling water reactor would be an example of the kind of continuous monitoring required. In addition, a basic monitoring program such as that outlined in table 1 might be conducted on a periodic basis in order to keep the surveillance system operable.

Although the previous discussion has been concerned with environmental surveillance requirements, it should be noted that the discharge of radioactive materials from nuclear facilities is

regulated by the Atomic Energy Commission so that the levels leaving the controlled area will not exceed concentrations established in Title 10, Part 20 of the Code of Federal Regulations (10CFR20) (*12*). In the case of the liquid effluent, average concentrations in the condenser water cooling canal at the point of discharge must stay within these limits. For gaseous discharges, the discharge rate is controlled and limits established so that average concentrations in the atmosphere will not exceed 10CFR20 values at the site boundary.

Multiple reactor sources

The large increase in the number of nuclear power plants has resulted in the location of more than one reactor at some sites. In addition, some reactor sites are planned to be sufficiently close together so that many will share the same air, water, and terrestrial environment. This trend dictates that potential environmental problems be assessed on an area or regional basis. These factors must now be considered in establishing both Bureau and State health agency environmental surveillance activities so that the radioactivity that might result from nuclear power sources can be evaluated over relatively large geographic areas. Such evaluations must consider the possible long-term buildup of radioactivity in the aquatic environment, including reconcentration phenomena in biological media that might result in population exposure. Multiple reactor sites also present regulatory problems relative to the establishment of radioactive effluent discharge limits. These limits will have to be developed carefully, using the best available information on the many environmental aspects that influence the possible population exposure to assure that the total dose to the population from multiple reactor sources is within acceptable limits based on Federal Radiation Council guidance.

Summary

An analysis of data from nuclear plants currently operating in the United States has shown that discharges of radioactive wastes have generally been small percentages of AEC regulatory limits and have resulted in minimal or undetectable radiation exposure to the population. Studies carried out to date by the Bureau of Radiological Health have confirmed this to be the case. If good waste management practices are carefully followed by reactor plant operators, the resulting radiation exposures to the public should continue to be extremely low. However, the existence of multiple reactor sites and areas containing several sites will require that monitoring programs be designed to consider the possibility of radiation effects from a large number of nuclear power sources.

Because of the large number of nuclear plants which will ultimately require surveillance programs, efforts are being made by the Bureau to reevaluate recommendations for environmental surveillance programs for maximum effectiveness. Results of field studies conducted thus far indicate that a surveillance program as previously described will satisfy public health requirements if the effluents are well defined and if the critical radionuclides in the effluents and pathways to the population are clearly identified.

The Bureau of Radiological Health will continue to carry out its responsibility for evaluating the environmental levels of radioactivity through a nationwide surveillance program, technical assistance to States, research and development activities, and the analysis of environmental radiation data from all sources. This function is currently being strengthened to insure an adequate evaluation of the impact of the growing nuclear power industry on radiation levels in the environment and the continued protection of the public health.

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SECTION I. MILK AND FOOD

Milk Surveillance, March 1970

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Bureau of Radiological Health and the Bureau of Foods, Pesticides and Product Safety, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations
Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in, or are formed as a result of, nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium–89, strontium–90, iodine–131, cesium–137, and barium–140. A sixth radionuclide, potassium–40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium–40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these con-

Figure 1. Milk sampling networks in the Western Hemisphere

centrations are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted in the period, July–September 1969, with 31 laboratories participating in an experiment on milk samples containing known concentrations of strontium–89, strontium–90, iodine–131, cesium–137, and barium–140. Of the 18 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 14 participated in the experiment.

The iodine–131 and cesium–137 results show much improvement over previous tests. Barium–140 results also look good which is encouraging, since this is the first time barium–140 was analyzed for this type of experiment. However, strontium–89 and strontium–90 analyses still need improvement (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium–40, iodine–131, cesium–137, and barium–140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports.*

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium–90 and cesium–137 are relatively stable over short time periods, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine–131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium–90 and cesium–137 in that analysis.

Practical reporting levels were developed by

the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium–89	5
Strontium–90	2
Iodine–131	10
Cesium–137	10
Barium–140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurement equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium–89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium–90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine–131, Cesium–137, Barium–140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine–131, cesium–137, and barium–140 there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance to Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8,9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result due to exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1-liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/a)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/a)	Corresponding continuous daily intake (pCi/day)	Range I[b] (pCi/day)	Range II[b] (pCi/day)	Range III[b] (pCi/day)
Strontium-89	Bone	[c] 1.5	0.5	[d] 2,000	0–200	200–2,000	2,000–20,000
	Bone marrow	[c] .5	.17				
Strontium-90	Bone	[c] 1.5	.5	[d] 200	0–20	20–200	200–2,000
	Bone marrow	[c] .5	.17				
Iodine-131	Thyroid	1.5	.5	100	0–10	10–100	100–1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0–360	360–3,600	3,600–36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age: cesium-137—infants.
[b] Based on an average intake of 1 liter of milk per day.
[c] A dose of 1.5 rad/a to the bone is estimated to result in a dose of 0.5 rad/a to the bone marrow.
[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.
[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protective Action Guides (*10,11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1- or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c] 1,110,000
Strontium-90	Bone marrow			[c] 51,000
Cesium-137	Whole body			[c] 720,000
Iodine-131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.
[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.
[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.
[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

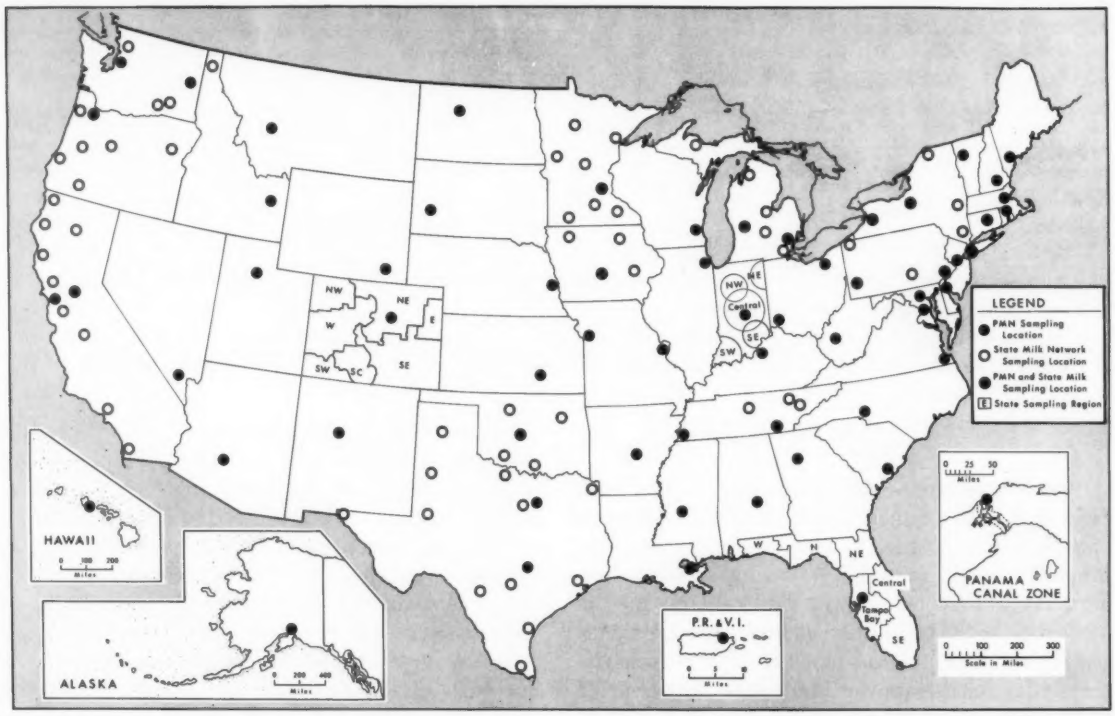

Figure 2. State and PMN milk sampling locations in the United States

as an estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2). The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium–90, iodine–131 and cesium–137 for March 1970 and the 12-month period, April 1969 to March 1970. Except where noted the monthly average represents a single sample for the sampling

Table 3. Concentration of radionuclides in milk for March 1970 and 12-month period, April 1969 through March 1970

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	8	7	0 (4)	0	7 (4)	9
Alaska:	Palmer[c]	P	5	6	0 (5)	0	3 (5)	5
Ariz:	Phoenix[c]	P	0	1	0 (4)	0	0 (4)	0
Ark:	Little Rock[c]	P	12	15	0 (5)	0	17 (5)	18
Calif:	Sacramento[c]	P	3	2	0 (4)	0	0 (4)	0
	San Francisco[c]	P	4	2	0 (4)	0	0 (4)	0
	Del Norte	P	23	19	0	0	24	19
	Fresno	P	2	2	0	0	0	5
	Humboldt	P	5	4	0	0	0	6
	Los Angeles	P	2	2	0	0	0	2
	Mendocino	P	4	3	0	0	0	4
	Sacramento	P	3	3	0	0	0	4
	San Diego	P	0	2	0	0	0	2
	Santa Clara	P	2	2	0	0	0	4
	Shasta	P	3	3	0	0	0	4
	Sonoma	P	3	2	0	0	0	4
Colo:	Denver[c]	P	6	5	0 (4)	0	0 (4)	1
	West	R	(d)		(e)	(e)	25	(e)
	Northeast	R	(d)		(e) (2)	(e)	(e) (2)	(e)
	East	R	(d)		(e)	(e)	(e)	(e)
	Southeast	R	(d)		(e)	(e)	(e)	(e)
	South central	R	(d)		NS	(e)	NS	(e)
	Southwest	R	(d)		(e)	(e)	35	(e)
	Northwest	R	(d)		NS	(e)	NS	(e)
Conn:	Hartford[c]	P	7	8	0 (4)	0	11 (4)	11
	Central	P	NS		NS		NS	
Del:	Wilmington[c]	P	10	8	0 (4)	0	6 (4)	5
D.C:	Washington[c]	P	8	7	0 (4)	0	5 (4)	5
Fla:	Tampa[c]	P	5	6	0 (4)	0	44 (4)	54
	West	R	8	11	0	0	0	22
	North	R	6	13	0	0	14	25
	Northeast	R	7	7	0	0	55	53
	Central	R	6	7	0	0	17	43
	Tampa Bay area	R	6	6	0	0	44	55
	Southeast	R	7	7	0	0	40	80
Ga:	Atlanta[c]	P	8	9	0 (4)	0	11 (4)	18
Hawaii:	Honolulu[c]	P	2	2	0 (5)	0	3 (5)	0
Idaho:	Idaho Falls[c]	P	3	5	0 (5)	0	0 (5)	3
Ill:	Chicago[c]	P	6	7	0 (5)	0	5 (5)	9
Ind:	Indianapolis[c]	P	8	8	0 (5)	0	2 (5)	4
	Northeast	P	8	10	0	1	10	11
	Southeast	P	12	9	0	0	15	11
	Central	P	10	9	0	0	0	10
	Southwest	P	9	10	0	0	10	13
	Northwest	P	10	10	0	0	10	17
Iowa:	Des Moines[c]	P	8	6	0 (4)	0	0 (4)	2
	Iowa City	P	NS		NS		NS	
	Des Moines	P	NS		NS		NS	
	Spencer	P	NS		NS		NS	
	Fredericksburg	P	NS		NS		NS	
Kans:	Wichita[c]	P	8	8	0 (5)	0	0 (5)	1
Ky:	Louisville[c]	P	8	8	0 (4)	0	3 (4)	4
La:	New Orleans[c]	P	13	16	0 (4)	0	20 (4)	18
Maine:	Portland[c]	P	9	11	0 (4)	0	17 (4)	23
Md:	Baltimore[c]	P	6	8	0 (5)	0	3 (5)	6
Mass:	Boston[c]	P	8	11	0 (5)	0	11 (5)	20
Mich:	Detroit[c]	P	8	8	0 (5)	0	9 (5)	8
	Grand Rapids[c]	P	6	9	0 (5)	0	10 (5)	11
	Bay City	P	6	7	(e) (3)	(e)	4 (3)	9
	Charlevoix	P	13	11	(e) (3)	(e)	17 (3)	18
	Detroit	P	6	6	(e) (5)	(e)	5 (5)	6
	Grand Rapids	P	9	8	(e) (5)	(e)	15 (5)	12
	Lansing	P	8	7	(e) (3)	(e)	15 (3)	14
	Marquette	P	14	11	(e) (2)	(e)	23 (2)	25
	Monroe	P	5	6	(e) (2)	(e)	11 (2)	2
	South Haven	P	NA	7	(e) (1)	(e)	13 (1)	11
Minn:	Minneapolis[c]	P	9	10	0 (5)	0	4 (5)	7
	Bemidji	P	13	17	0	0	20	24
	Mankato	P	6	8	0	0	12	0
	Rochester	P	7	8	0	0	0	0
	Duluth	P	12	18	0	0	25	22
	Worthington	P	5	7	0	0	0	0
	Minneapolis	P	8	12	0	0	14	0
	Fergus Falls	P	5	9	0	0	14	0
	Little Falls	P	10	9	0	0	20	0
Miss:	Jackson[c]	P	9	12	0 (5)	0	7 (5)	13
Mo:	Kansas City[c]	P	6	8	0 (4)	0	0 (4)	1
	St. Louis[c]	P	4	8	0 (4)	0	3 (4)	2
Mont:	Helena[c]	P	4	5	0 (4)	0	5 (4)	5
Nebr:	Omaha[c]	P	7	6	0 (3)	0	0 (3)	1
Nev:	Las Vegas[c]	P	2	0	0 (5)	0	0 (5)	0
N.H:	Manchester[c]	P	8	8	0 (5)	0	8 (5)	18

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for March 1970 and 12-month period, April 1969 through March 1970—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium–90		Iodine–131		Cesium–137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
N.J:	Trenton[c]	P	7	9	0 (5)	0	4 (5)	6
N.Mex:	Albuquerque[c]	P	4	3	0 (5)	0	0 (5)	0
N.Y:	Buffalo[c]	P	6	7	0 (4)	0	12 (4)	8
	New York City[c]	P	10	10	0 (5)	0	13 (5)	12
	Syracuse[c]	P	8	7	0 (5)	0	9 (5)	9
	Albany	P	(e)	4	0 (6)	0	(e) (6)	(e)
	Buffalo	P	(e) (2)	(e)	0 (2)	0	(e) (2)	(e)
	Massena	P	(e) (3)	7	0 (2)	0	22 (2)	(e)
	Newburg	P	12	6	0 (1)	0	(e)	(e)
	New York City	P	(e) (5)	7	0 (5)	0	(e) (5)	(e)
	Syracuse	P	(e)	3	0	0	(e) (2)	(e)
N.C:	Charlotte[c]	P	11	12	0 (5)	0	14 (5)	13
N.Dak:	Minot[c]	P	12	10	0 (5)	0	16 (5)	14
Ohio:	Cincinnati[c]	P	6	8	0 (4)	0	7 (4)	2
	Cleveland[c]	P	9	9	0 (4)	0	6 (4)	5
Oklahoma:	Oklahoma City[c]	P	6	7	0 (5)	0	3 (5)	8
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Ore:	Portland[c]	P	8	7	0 (4)	0	5 (4)	6
	Baker	P	4	3	(e)	(e)	0	0
	Coos Bay	P	4	6	(e)	(e)	0	0
	Eugene	P	2	3	(e)	(e)	0	0
	Medford	P	3	2	(e)	(e)	0	0
	Portland composite	P	7	4	(e)	(e)	0 (4)	6
	Portland local	P	4	5	(e)	(e)	0 (4)	9
	Redmond	P	6	2	(e)	(e)	0	3
	Tillamook	P	9	7	(e)	(e)	20	16
Pa:	Philadelphia[c]	P	8	9	0 (3)	0	8 (3)	4
	Pittsburgh[c]	P	10	11	0 (5)	0	11 (5)	8
	Dauphin	P	4	7	0	2	0	15
	Erie	P	10	10	13	7	21	24
	Philadelphia	P	7	8	0	5	11	13
	Pittsburgh	P	6	11	0	3	29	20
R.I:	Providence[c]	P	7	9	0 (4)	0	5 (4)	15
S.C:	Charleston[c]	P	9	10	0 (4)	0	18 (4)	23
S.Dak:	Rapid City[c]	P	6	8	0 (4)	0	0 (4)	4
Tenn:	Chattanooga[c]	P	9	10	0 (3)	0	4 (3)	12
	Memphis[c]	P	8	9	0 (4)	0	2 (4)	4
	Chattanooga	P	9	12	0 (5)	0	13 (5)	14
	Clinton	P	17	16	0 (2)	1	12 (2)	12
	Knoxville	P	7	7	0 (2)	0	17 (2)	5
	Nashville	P	7	8	0	0	16 (2)	6
	Fayetteville	P	7	7	0	0	21 (2)	21
Tex:	Austin[c]	P	4	2	0 (5)	0	3 (5)	4
	Dallas[c]	P	6	6	0 (4)	0	11 (4)	6
	Amarillo	R	2	4	0	0	0	0
	Corpus Christi	R	NS	5	NS	0	NS	2
	El Paso	R	NS	2	NS	0	NS	0
	Fort Worth	R	NS	6	NS	0	NS	5
	Harlingen	R	4	3	0	0	0	0
	Houston	R	NS	8	NS	0	NS	15
	Lubbock	R	NS	4	NS	0	NS	0
	Midland	R	NS	2	NS	0	NS	0
	San Antonio	R	4	4	0	0	0	0
	Texarkana	R	NS	11	NS	0	NS	12
	Uvalde	R	NS	2	NS	0	NS	0
	Wichita Falls	R	NS	7	NS	0	NS	8
Utah:	Salt Lake City[c]	P	3	4	0 (5)	0	0 (5)	3
Vt:	Burlington[c]	P	8	8	0 (4)	0	9 (4)	12
Va:	Norfolk[c]	P	9	10	0 (4)	0	6 (4)	8
Wash:	Seattle[c]	P	7	7	0 (4)	0	0 (4)	9
	Spokane[c]	P	5	6	0 (5)	0	2 (5)	3
	Benton County	R	0	1	0	0	0	7
	Franklin County	R	NS	2	NS	0	NS	2
	Sandpoint, Idaho	R	7	11	0	0	18	26
	Skagit County	R	4	7	0	0	14	13
W.Va:	Charleston[c]	P	10	9	0 (4)	0	4 (4)	5
Wisc:	Milwaukee[c]	P	6	7	0 (4)	0	12 (4)	10
Wyo:	Laramie[c]	P	6	5	0 (4)	0	0 (4)	2
CANADA:								
Alberta:	Calgary	P	8	8	(d)		27	17
	Edmonton	P	6	7	(d)		24	16
British Columbia:	Vancouver	P	11	10	(d)		21	31
Manitoba:	Winnipeg	P	8	8	(d)		21	24
New Brunswick:	Frederickton	P	10	13	(d)		26	19
Newfoundland:	St. Johns	P	11	17	(d)		32	34

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for March 1970 and 12-month period, April 1969 through March 1970—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium–90		Iodine–131		Cesium–137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA—Continued								
Nova Scotia:	Halifax	P	9	10	[d]		15	20
Ontario:	Ft. William	P	14	15	[d]		29	29
	Ottawa	P	5	8	[d]		16	13
Ontario:	Sault Ste. Marie	P	14	14	[d]		29	29
	Toronto	P	5	5	[d]		29	10
	Windsor	P	4	5	[d]		9	9
Quebec:	Montreal	P	7	8	[d]		16	17
	Quebec	P	9	11	[d]		26	26
Saskatchewan:	Regina	P	8	7	[d]		16	12
	Saskatoon	P	9	7	[d]		8	10
CENTRAL AND SOUTH AMERICA:								
Columbia:	Bogota	P	2	2	0	0	0	3
Chile:	Santiago	P	0	0	0	0	0	2
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Montego Bay	P	6	5	0	0	150	95
Venezuela:	Caracas	P	2	2	0	0	0	0
Canal Zone:	Cristobal[c]	P	0	0	0 (5)	0	9 (5)	9
Puerto Rico:	San Juan[c]	P	3	3	0 (4)	0	5 (4)	8
PMN network average[f]			7	7	0	0	6	8

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or national network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine–131: Colorado—25 pCi/liter; Michigan—14 pCi/liter; Oregon—15 pCi/liter
Cesium–137: Colorado—25 pCi/liter; New York—20 pCi/liter; Oregon—15 pCi/liter
Strontium–90: New York—3pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS Pasteurized Milk Network stations denoted by footnote [c].

NA, no analysis.
NS, no sample.

station. Strontium–89 and barium–140 data have been omitted from table 3 since levels at the great majority of the stations for March 1970 were below the respective practical reporting levels. The following station averages reflect samples in which strontium–89 was detected: Calif., Del Norte (State) 27 pCi/liter and Humboldt (State) 6 pCi/liter.

Iodine–131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine–131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium–90 monthly averages ranged from 0 to 23 pCi/liter in the United States for the month of March 1970 and the highest 12–month average was 19 pCi/liter (Del Norte, Calif.), representing 9.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium–137 monthly averages ranged from 0 to 55 pCi/liter in the United States for the month of March 1970 and the highest 12-month average was 80 pCi/liter (Southeast Fla.), representing 2.2 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium–137 levels that have been observed in Florida (*12*) and Jamaica. Iodine–131 results for individual samples were all below the practical reporting level with the exception of Erie, Pa. (State) 13 pCi/liter.

Acknowledgement

Appreciation is expressed to the personnel of the following health agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiological Health Section
Division of Air, Occupational and Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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(12) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER, and B. KAHN. The Cause of Relatively High Cesium–137 Concentrations in Tampa, Florida, Milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Issue
Connecticut Diet Study	July–December 1968 and January–June 1969	February 1970
California Diet Study	October–December 1968 and January–March 1969	May 1970
Radionuclides in Institutional Diet Samples, *HASL*	July–September 1969	June 1970
Tri-City Diet Study,	January–December 1969	June 1970

SECTION II. WATER

The Public Health Service, the Federal Water Quality Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unindentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	January–June 1968	December 1969
Coast Guard Water Supplies	January 1968–July 1969	February 1970
Florida	1968	March 1970
Minnesota	January–June 1969	January 1970
New York	July–December 1968	September 1969
North Carolina	January–December 1967	May 1969
Washington	July 1967–June 1968	June 1969

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(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

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Radiostrontium in Tap Water, January-December 1969[1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium–90 in tap water at New York City since August 1954. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is is available for analysis. Cesium–137 determinations were begun in January 1964. The analytical methods used at the laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Strontium–90 concentration and cesium–137 to strontium–90 ratios in New York City tap water for January through December 1969 are presented in table 1. These results appear graphically in figure 1.

A decreasing trend has been observed in the strontium–90 concentration since the July 1963 peak. The maximum strontium–90 concentrations observed are below the acceptable limit as set forth in the interstate carrier drinking water standards (*2*).

[1] Prepared from information appearing in Fallout Program Quarterly Summary Report, HASL 224. This report is available from the Clearinghouse for Federal Scientific and Technical Information, CESTI, 5285 Port Royal Road, Springfield, Va. 22151.

Table 1. Radiostrontium in New York City tap water January–December 1969

Date	Strontium-90[a] (pCi/liter)	Cesium-137/ strontium-90
January	0.58	0.08
February	.68	.06
March	.56	.08
April	.54	NA
May	.69	.08
June	.66	.10
July	.74	.08
August	.74	.09
September	.84	.10
October	.76	.09
November	.78	.08
December	.90	.08

[a] Approximately 100 liters per sample.
NA, no analysis.

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(*1*) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures 40:E–38–01–16. Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York, N.Y. 10014.

(*2*) FEDERAL REGISTER RULES AND REGULATIONS. Title 42-Public Health, Chapter 1, Public Health Service, Department of Health, Education and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards 27:2154–2155. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

Recent coverage in *Radiological Health Data and Reports.*

Period	Issue
January–June 1968	April 1969
July–December 1968	November 1969

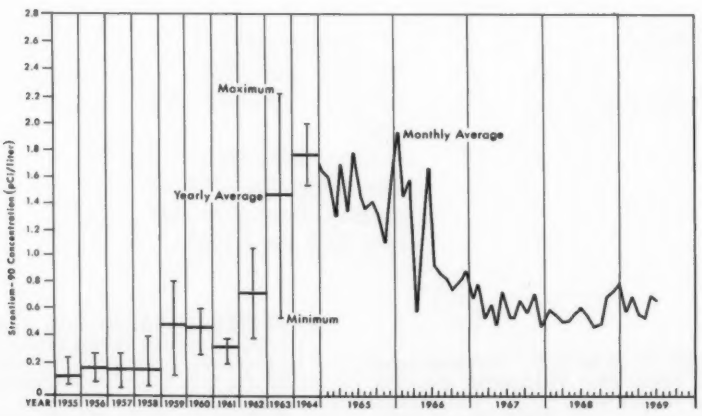

Figure 1. Strontium–90 concentrations in New York City tap water 1955–1969

Tritium in Surface Water Network, July-December 1969

Bureau of Radiological Health
U.S. Public Health Services

The tritium sampling network was established by the Public Health Service in May 1964 to measure and monitor tritium concentrations in major river systems in the United States and to provide surveillance at selected surface water stations downstream from nuclear facilities. The network originally consisted of 10 stations selected from the 131 existing water pollution sampling stations operated by the Federal Water Quality Administration (FWQA); eight of the stations were located downstream from nuclear facilities and two stations served to establish baseline levels (figure 1). Two of these stations have been discontinued due to the difficulty of locating a new sampling point and the shutdown of a reactor.

Monthly composites of weekly samples are collected through the FWQA and sent to the Southeastern Radiological Health Laboratory for analysis. The analyses are carried out using liquid scintillation counting techniques described by Moghissi et al (*1*). The minimum level of detectability is 0.2 nCi/liter.

Data for the samples collected during the last 6 months of 1969 are shown in table 1. Station averages for this period and the corresponding period of 1968 are also presented in the table. The highest concentration observed during the last 6 months of 1969 was 5.3 nCi/liter (Clinch River—Kingston, Tenn.). The highest 6-month average, 2.7 nCi/liter, was also observed at the Clinch River station. Assuming that the specific activity of tritium in the body is essentially the same as that in the surface water, this average concentration corresponds to an estimated whole-

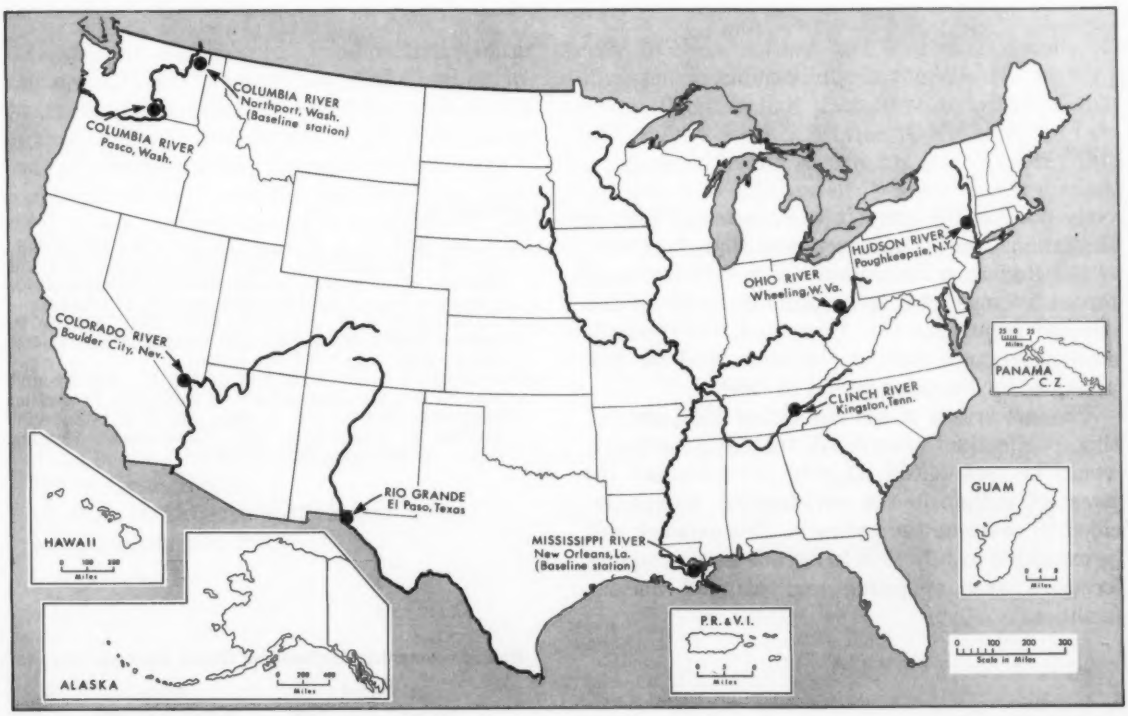

Figure 1. Sampling stations for tritium in surface waters

Table 1. Tritium concentration in surface waters, July–December 1969

Collection site	Concentration[a] (nCi/liter)							
	1969						July–December average[b] for:	
	July	August	September	October	November	December	1968	1969
Clinch River: Kingston, Tenn.	1.7 ± 0.2	1.4 ± 0.3	1.3 ± 0.3	1.2 ± 0.1	5.0 ± 0.3	5.3 ± 0.3	1.7	2.7
Colorado River: Boulder City, Nev.[c]	1.4 ± .2	NS	1.5 ± .2	1.4 ± .2	1.4 ± .2	1.2 ± 0.2	1.8	1.4
Columbia River: Northport, Wash.[c]	NS	.7 ± .2	.7 ± .2	NS	.8 ± .2	NS	.8	.7
Columbia River: Pasco, Wash.	.9 ± .2	.6 ± .2	.8 ± .2	.7 ± .2	1.0 ± .2	NS	.8	.8
Hudson River: Poughkeepsie, N.Y.	.2 ± .2	.4 ± .2	.4 ± .2	.6 ± .2	.4 ± .2	[d]<.2	.5	.3
Mississippi River: New Orleans, La.	.6 ± .2	<.2	<.2	NS	<.2	NS	.6	.2
Ohio River: Wheeling, W.Va.	.2 ± .2	.5 ± .2	.7 ± .2	NS	<.2	.4 ± .2	.2	.3
Rio Grande: El Paso, Tex.	.2 ± .2	0.3 ± .2	.2 ± .2	<.2	.2 ± .2	.2 ± .2	.2	.1

[a] The error reported is the 2-sigma error at the 95-percent confidence level.
[b] Values less than or equal to the minimum level of detectability (0.2 nCi/liter) were averaged as zero.
[c] Baseline station.
[d] Values are not statistically significant at the 95-percent confidence level.
NS, no sample.

body dose[1] of 0.4 mrem/a or in terms of Federal Radiation Council guidance, less than 1 percent of the Radiation Protection Guide (170 mrem/a) for an average dose to a suitable sample of the exposed population (*3*). In general, the 6-month station averages were at the same level for this period as for the same period in 1968.

The last article in the November 1969 issue of this publication announced that this network would be terminated. Due to the increased interest of tritium in the environment, it was decided to continue the network. This network will be expanded in July 1970 to include more sampling locations near operating and planned nuclear facilities.

[1] Development of the calculations to obtain this dose may be found in reference (*2*).

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Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	November 1968
July–December 1968	June 1969
January–June 1969	November 1969

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports.*

Network	Period	Issue
Fallout in the United States and Other Areas, *HASL*	January–June 1968	October 1969
Plutonium in Airborne Particulates and Precipitation, *PHS*	July–September 1968	February 1970

1. Radiation Alert Network March 1970

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during March 1970. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, March 1970

Station location		Air surveillance				Last profile in RHD&R	Precipitation				
		Number of samples	Gross beta radioactivity (pCi/m³)				Number of samples	Total depth (mm)	Field estimation of deposition		
			Maximum	Minimum	Average[a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	21	4	0	1	Dec 69	3	51	3	51	11
Alaska:	Adak	[b]				Dec 69	[c]				
	Anchorage	8	0	0	0	June 70	[c]				
	Attu Island	18	0	0	0	Jan 70	[c]				
	Fairbanks	22	0	0	0	July 70	2	5	2	5	3
	Juneau	[b]				Oct 69	[c]				
	Kodiak	[b]				Nov 69	[c]				
	Nome	8	1	0	1	Mar 70	[c]				
	Point Barrow	[b]				Feb 70	[c]				
	St. Paul Island	[b]				Apr 70	[c]				
Ariz:	Phoenix	18	8	1	3	Oct 69	[c]				
Ark:	Little Rock	[b]				June 70	[c]				
Calif:	Berkeley	22	1	0	0	Nov 69	4	40	4	40	0
	Los Angeles	22	3	0	1	Mar 70	[c]				
C.Z:	Ancon	16	0	0	0	Nov 69	[c]				
Colo:	Denver	22	9	0	4	Nov 69	5	17	[d]		
Conn:	Hartford	19	1	0	0	July 70	7	59	7	59	11
Del:	Dover	21	1	0	0	May 70	[c]				
D.C:	Washington	24	2	0	0	Feb 70	[c]				
Fla:	Jacksonville	22	1	0	1	June 70	7	154	7	154	17
	Miami	14	0	0	0	July 70	4	82	4	82	0
Ga:	Atlanta	22	3	1	1	Apr 70	1	180	1	180	6
Guam:	Agana	[b]				May 70	[c]				
Hawaii:	Honolulu	25	2	0	1	Jan 70	1	7	[d]		
Idaho:	Boise	22	2	0	1	Jan 70	7	36	7	36	3
Ill:	Springfield	19	5	0	1	Feb 70	[c]				
Ind:	Indianapolis	[b]				Apr 70	[c]				
Iowa:	Iowa City	19	1	0	1	Nov 69	6	112	6	112	0
Kans:	Topeka	22	4	1	2	June 70	5	19	5	19	1
Ky:	Frankfort	8	1	0	1	Feb 70	[c]				
La:	New Orleans	12	0	0	0	Feb 70	8	196	[d]		
Maine:	Augusta	22	1	0	0	Mar 70	7	96	7	96	0
Md:	Baltimore	20	1	0	0	July 70	8	69	8	69	24
	Rockville	11	2	0	0	Jan 70	[c]				
Mass:	Lawrence	20	1	0	0	May 70	5	94	5	94	2
	Winchester	21	1	0	0	Dec 69	7	97	7	97	0
Mich:	Lansing	20	1	0	0	Jan 70	[c]				
Minn:	Minneapolis	21	0	0	0	May 70	4	58	4	58	9
Miss:	Jackson	14	1	0	0	Mar 70	4	144	4	144	49
Mo:	Jefferson City	22	2	0	1	Apr 70	7	41	7	41	0
Mont:	Helena	18	1	0	1	Dec 69	3	25	3	25	12
Nebr:	Lincoln	16	5	0	2	Apr 70	4	30	4	30	7
Nev:	Las Vegas	13	2	0	1	July 70	[c]				
N.H:	Concord	[b]				Feb 70	[c]				
N.J:	Trenton	20	1	0	0	Mar 70	7	104	7	104	7
N.Mex:	Santa Fe	15	3	0	1	Dec 69	4	16	4	16	1
N.Y:	Albany	[b]				Apr 70	[c]				
	Buffalo	21	1	0	0	Nov 69	[c]				
	New York City	8	1	0	0	Dec 69	[c]				
N.C:	Gastonia	15	11	1	3	Nov 69	4	32	[d]		
N.Dak:	Bismarck	21	1	0	0	Feb 70	5	26	5	26	1
Ohio:	Cincinnati	[b]				May 70	[c]				
	Columbus	5	1	0	1	Mar 70	[c]				
	Painesville	19	1	0	1	July 70	8	53	8	53	13
Okla:	Oklahoma City	[b]				Jan 70	[c]				
	Ponca City	21	11	0	2	July 70	6	37	6	37	0
Ore:	Portland	22	1	0	0	Apr 70	9	76	9	76	5
Pa:	Harrisburg	17	1	0	0	Apr 70	1	23	1	23	6
P.R:	San Juan	6	5	1	3	Mar 70	[c]				
R.I:	Providence	19	2	0	1	Jan 70	2	56	2	56	7
S.C:	Columbia	19	4	0	1	Dec 69	3	157	3	157	29
S.Dak:	Pierre	13	2	1	1	Oct 69	[c]				
Tenn:	Nashville	21	2	0	1	Jan 70	9	92	9	92	14
Tex:	Austin	13	4	0	2	May 70	[c]				
	El Paso	[b]				Feb 70	[c]				
Utah	Salt Lake City	31	4	0	1	Mar 70	8	30	8	30	1
Vt:	Barre	13	1	0	0	June 70	4	33	4	33	2
Va:	Richmond	22	1	0	0	June 70	7	91	7	91	12
Wash:	Seattle	25	0	0	0	June 70	7	54	[d]		
	Spokane	19	1	0	1	May 70	[c]				
W.Va:	Charleston	16	2	0	1	Dec 69	9	60	9	60	7
Wisc:	Madison	22	1	0	0	June 70	4	27	4	27	7
Wyo:	Cheyenne	22	4	0	2	July 70	5	330	5	330	27
Network summary		1,089	11	0	1		5	73	5	74	8

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.

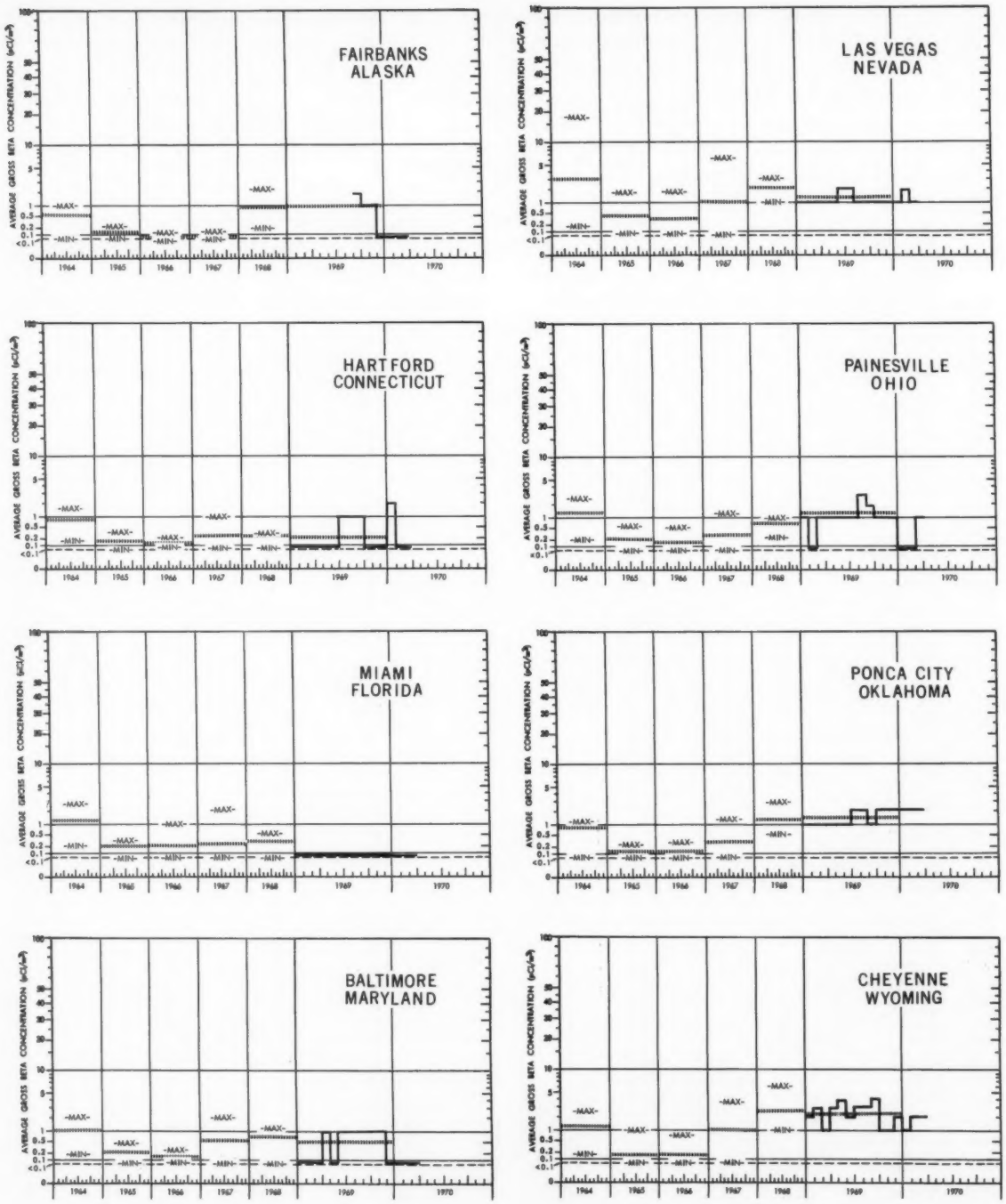

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1963–March 1970

2. Canadian Air and Precipitation Monitoring Program[1], March 1970

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for March 1970 are presented in table 2.

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, March 1970

Station	Number of samples	Air surveillance, gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	31	0.3	0.0	0.1	46	1.0
Coral Harbour	27	.2	.0	.1	84	1.2
Edmonton	31	.1	.0	.1	41	1.1
Ft. Churchill	30	.2	.1	.1	38	.7
Fredericton	30	.3	.0	.0	32	2.1
Goose Bay	31	.2	.0	.0	15	1.4
Halifax	31	.4	.0	.1	28	3.2
Inuvik	31	.1	.0	.1	25	.2
Montreal	30	.4	.0	.1	99	5.2
Moosonee	31	.3	.1	.1	11	.2
Ottawa	31	.2	.1	.1	125	6.4
Quebec	30	.3	.0	.1	35	2.9
Regina	31	.2	.0	.1	27	.4
Resolute	31	.3	.0	.1	37	.1
St. John's, Nfld.	30	.2	.0	.1	38	5.2
Saskatoon	31	.2	.0	.1	1	.1
Sault Ste. Marie	30	.2	.1	.1	72	1.0
Thunder Bay	31	.2	.1	.1	34	1.3
Toronto	31	.3	.0	.1	87	4.4
Vancouver	31	.2	.0	.1	71	4.2
Whitehorse	30	.1	.0	.1	ND	.4
Windsor	31	.2	.0	.1	73	3.9
Winnipeg	31	.2	.0	.1	18	.5
Yellowknife	31	.2	.1	.1	2	.1
Network summary	733	0.4	0.0	0.1	45	1.9

ND, nondetectable.

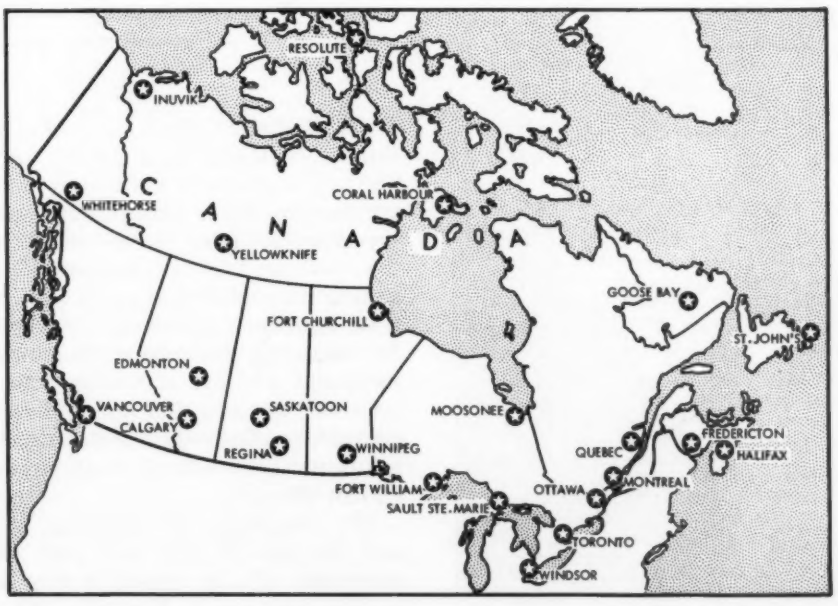

Figure 3. Canadian air and precipitation sampling stations

3. Pan American Air Sampling Program March 1970

Pan American Health Organization and
U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 4. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports*. The March 1970 air monitoring results from the participating countries are given in table 3.

Table 3. Summary of gross beta radioactivity in Pan American surface air, March 1970

Station		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average
Argentina:	Buenos Aires	NS	NS	NS	NS
Bolivia:	La Paz	NS	NS	NS	NS
Chile:	Santiago	30	0.14	0.02	0.08
Colombia:	Bogota	18	.14	.02	.06
Ecuador:	Cuenca	NS	NS	NS	NS
	Guayaquil	NS	NS	NS	NS
	Quito	NS	NS	NS	NS
Guyana:	Georgetown	11	.32	.05	.15
Jamaica:	Kingston	NS	NS	NS	NS
Peru:	Lima	21	.13	.04	.05
Venezuela:	Caracas	12	1.32	.01	.08
West Indies:	Trinidad	13	.24	.08	.17
Pan American summary		105	1.32	0.01	0.09

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.
NS, no sample.

Figure 4. Pan American Air Sampling Program stations

4. Tritium in Precipitation (RAN) July–December 1969

Bureau of Radiological Health
U.S. Public Health Service

The Radiation Alert Network (RAN) of the Bureau of Radiological Health, Public Health Service, established a tritium in precipitation program in 1967. Nine stations were selected covering the United States, including Alaska and the Hawaiian Islands. The locations of these stations are indicated in figure 1.

Rain analysis represents a sensitive technique for monitoring of tritium in the environment. Any significant addition of tritium into the natural cycle can be easily and rapidly detected by rain analysis, primarily due to considerable improvements in the low-level counting techniques for tritium (*6*).

The procedure for analyzing these samples and the data for 1967 and 1968 were reported previously (*7*). As stated in this reference the samples were sent to Rockville, Md., composited by months and aliquots of the composite shipped to the Southeastern Radiological Health Labora-

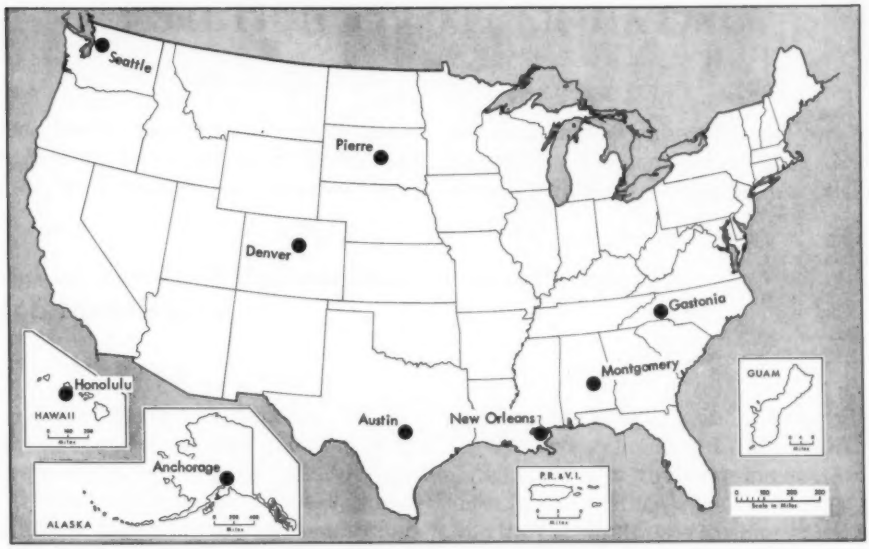

Figure 5. Tritium precipitation stations

Table 4. Tritium analysis of precipitation from RAN stations July–December 1969

Location	Concentration (nCi/liter)					
	July	Aug	Sept	Oct	Nov	Dec
Alaska: Anchorage	NS	NS	NS	0.2	<0.2	<0.2
Ala: Montgomery	<0.2	<0.2	0.7±0.2	0.4±0.2	0.3±0.2	<.2
Colo: Denver	NS	NS	NS	.3± .2	.4± .2	<.2
Hawaii: Honolulu	NS	NS	NS	<.2	<.2	NS
La: New Orleans	NS	NS	<.2	<.2	<.2	<.2
N.C: Gastonia	NS	NS	NS	<.2	<.2	<.2
S. Dak: Pierre	NS	NS	NS	NS	NS	NS
Tex: Austin	NS	NS	NS	<.2	<.2	<.2
Wash: Seattle	NS	NS	NS	<.2	<.2	<.2

NS, no sample.

tory (SERHL). As of October 1, 1969, all samples are sent directly to SERHL and are no longer handled at Rockville, Md.

The data for the last 6 months of 1969 appear in table 4. The concentration of tritium at these stations for this period remain at the same level as previously reported.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–December 1967 and 1968	March 1970
January–June 1969	June 1970

REFERENCES

(1) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

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(6) MOGHISSI, A. A. Analysis and Public Health Aspects of Environmental Tritium, Radionuclides in the Environment. Advances in Chemistry Series, No. 93. American Chemical Society, Washington, D. C. (1970) pp. 419–426.

(7) MOGHISSI, A. A. and C. R. PORTER. Tritium concentration in precipitation, 1967–1968. Radiol Health Data Rep 11:137–140 (March 1970).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Argonne National Laboratory and the S1C Prototype Reactor Facility.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Argonne National Laboratory[2] January–June 1969

University of Chicago
Lemont, Ill.

The radioactivity of the environment is determined on a continuing basis by measuring the radioactivity in naturally-occurring materials collected both on and off the Argonne National Laboratory site. Since radioactivity is usually spread by air and water, the environmental monitoring program at Argonne has concentrated on these materials. The sampling locations discussed in this report are shown in figures 1 and 2.

Air monitoring

Air-filter samples were collected continuously at seven locations on the Argonne site and at five locations off the site. The alpha and beta radioactivity in air-filter samples are summarized in table 1; the average concentrations of gamma-ray emitters as determined by gamma-ray spectrometry are summarized in table 2. The alpha radioactivity concentrations were due principally to naturally-occurring radionuclides and were in the range found in previous years. As in the past, much of the beta and gamma radioactivity was due to fission and neutron activation products from nuclear detonations, although about one-third of the gamma radioactivity and a smaller fraction of the beta radioactivity were due to beryllium–7, produced continuously in the upper atmosphere by cosmic-ray interactions. The variation in total beta radioactivity during the year can be correlated with the concentrations of the individual gamma-ray emitters. The steady increase in total beta radioactivity from January to June 1969 can be correlated with the concentrations of the individual gamma-ray emitters. All the gamma-ray emitters for which positive results were obtained, including the naturally-occurring beryllium–7, increased in concentration from March through June 1969. This behavior

[2] Summarized from "Environmental Radioactivity at Argonne National Laboratory, January–June 1969," University of Chicago, Lemont, Ill.

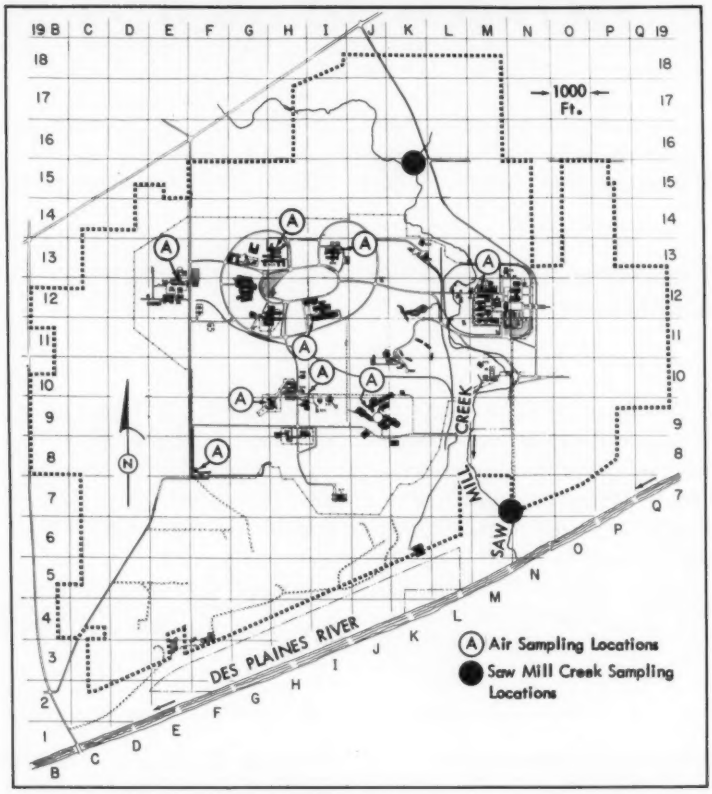

Figure 1. Onsite sampling locations at Argonne National Laboratory

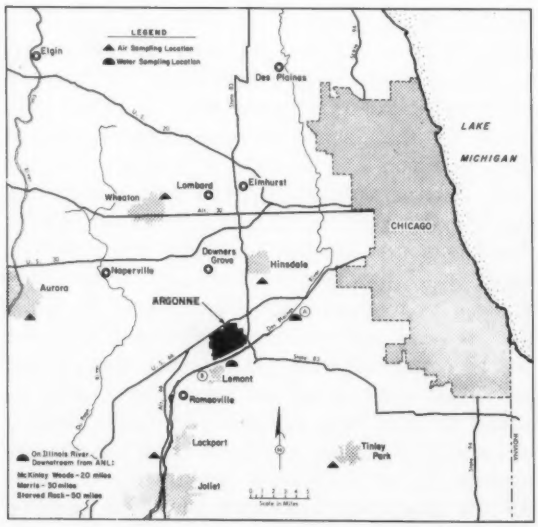

Figure 2. Location of Argonne National Laboratory (including some offsite sampling stations)

is attributed to the usual "spring maximum" in stratospheric fallout. Most of the fission products in the samples were injected into the atmosphere several months before they were observed, probably about December 1968, since the shortest-lived fission product detected in the spring was cerium–141 and the most abundant fission products were zirconium–95 and niobium–95. The presence of a very small amount of barium–140 ($\sim$1 fCi/m^3) in the air during the middle of January supports the suggestion that most of the fission product fallout originated in December 1968. The delay in its appearance implies high-altitude injection, or possibly an increased spring fallout rate from the troposphere by rain washout.

The average beta radioactivity during the first half of 1969 was very similar to 1968, as were the relative abundances of the fission products. Zirconium-niobium–95 was the predominant fission product during both periods.

Table 1. Alpha and beta radioactivity in air-filter samples[a], Argonne, January–June 1969

Period	Location	Number of samples	Alpha radioactivity (fCi/m³)			Beta radioactivity (pCi/m³)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
January	Onsite	30	2.3	0.9	4.4	0.07	0.04	0.10
	Offsite	25	3.0	1.2	5.1	.08	.06	.15
February	Onsite	23	3.3	2.0	5.5	.10	.05	.17
	Offsite	18	3.9	2.6	7.2	.11	.07	.16
March	Onsite	24	3.8	1.8	5.6	.13	.08	.20
	Offsite	20	4.4	3.2	8.9	.18	.12	.61
April	Onsite	27	3.8	2.3	5.9	.18	.09	.26
	Offsite	23	4.3	2.7	7.1	.21	.14	.40
May	Onsite	24	3.9	1.6	8.1	.31	.16	.52
	Offsite	21	4.1	.5	7.6	.33	.06	.54
June	Onsite	24	3.3	.7	5.8	.34	.12	.52
	Offsite	22	4.0	2.5	6.6	.39	.20	.55
Summary	Onsite	152	3.4	0.7	8.1	0.19	0.04	0.52
	Offsite	129	4.0	0.5	8.9	0.22	0.06	0.61

[a] These results were obtained by measuring the samples 4 days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products.

Table 2. Gamma-ray radioactivity in air-filter samples, Argonne, January–June 1969

Radionuclide	Location	Concentration (pCi/m³)						
		January	February	March	April	May	June	Average
Barium–lanthanum-140	Onsite	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Offsite	< .01	< .01	< .01	< .01	< .01	< .01	< .01
Beryllium-7	Onsite	.06	.05	.07	.08	.08	.11	.08
	Offsite	.05	.04	.07	.10	.09	.12	.08
Cerium-141	Onsite	< .01	< .01	< .01	.01	.02	.02	.01
	Offsite	< .01	< .01	< .01	.01	.02	.02	.01
Cerium-144	Onsite	< .01	.01	.02	.02	.03	.04	.02
	Offsite	< .01	.01	.02	.02	.03	.05	.02
Cesium-137	Onsite	< .01	< .01	< .01	< .01	< .01	< .01	< .01
	Offsite	< .01	< .01	< .01	< .01	< .01	< .01	< .01
Iodine-131	Onsite	< .01	< .01	< .01	< .01	< .01	< .01	< .01
	Offsite	< .01	< .01	< .01	< .01	< .01	< .01	< .01
Ruthenium-103	Onsite	< .01	< .01	.01	.01	.03	.03	.02
	Offsite	< .01	< .01	.01	.02	.03	.03	.02
Ruthenium–rhodium-106	Onsite	.02	.03	.05	.06	.06	.07	.05
	Offsite	.02	.03	.05	.07	.07	.08	.05
Zirconium–niobium-95	Onsite	< .01	< .01	.01	.03	.07	.11	.04
	Offsite	< .01	< .01	.01	.04	.08	.13	.05

The same fission products detected in the air-filter samples were also present in precipitation samples, and the beta and gamma radioactivities of these samples also increased during the spring months. Large volume rain samples were collected monthly and analyzed for iron–55. The average monthly concentrations ranged from 39 to 890 pCi/m² of surface. The average, 300 pCi/m², was six times higher than the previous 6-month period, principally because of one large value in in June 1969 (890 pCi/m²). Iron–55 is a neutron activation product and was produced mainly in nuclear tests conducted in September and October 1961. Therefore, the above concentrations have been corrected for decay to October 15, 1961, for comparison purposes. Except for May, the iron–55 concentrations also show a "spring maximum". The neutron activation products, tungsten–181–185, were also detected in some of the rain samples.

Air sampling for argon–41, a beta-particle emitter with a 1.8 hour half-life produced in an operating reactor by the action of neutrons on the stable argon in air, was conducted near the Juggernaut reactor (building 335) from March through June. The results are tabulated in table 3. These concentrations are based on 1-minute grab samples taken at a position downwind from the reactor at a point favorable for argon–41 detec-

Table 3. Argon–41 concentrations near Juggernaut reactor March–June 1969

Month	Number of samples	Number of samples >20 nCi/m³	Concentration[a] (nCi/m³)		Percent of AEC standard	
			Average	Maximum	Average	Maximum
March	6	0	—	<20	—	<50
April	22	12	43	133	110	330
May	24	11	33	140	83	350
June	28	11	21	86	53	220
Summary	80	34	27	140	70	350

[a] Minimum detectable concentration—20 nCi/m³.

tion after the reactor had been in operation for several hours. Therefore, the actual average concentration per 24-hour day in the vicinity of the reactor was much less than the values in the table. The argon–41 concentration in the exhaust from the Juggernaut is about 260 μCi/m³, so the average dilution by outside air in the samples collected was about a factor of 1,000. In 1968, argon–41 concentrations were measured in the vicinity of the CP–5 reactor (building 330), which operates at a power level about 20 times higher than Juggernaut. The CP-5 reactor is undergoing rehabilitation and is not being operated this year. A comparison of the argon–41 concentration near the two reactors is of interest. In 1968, argon–41 was detected in about 46 percent of the samples collected near CP-5. The average concentration was 140 nCi/m³. The fraction of positive results near the Juggernaut reactor was quite similar, 43 percent, while the average concentration, 27 nCi/m³, was five times smaller. In the CP-5 reactor the air that is exposed to neutrons is diluted with a large volume of inactive air before it is discharged. This means that the argon–41 concentrations in the air leaving the two reactor buildings are not greatly different, although the volume of air (containing argon–41) is about 15 times greater from CP–5. As a result, the argon–41 concentration in outside air averaged only five times less near the Juggernaut although the argon–41 production is about 20 times less than CP–5.

Air was sampled for tritiated (hydrogen–3) water vapor 50 yards west of the CP-5 reactor by absorbing the water vapor from the air on silica gel. The silica gel was heated to collect the water, whose tritium content was measured. The results are given in table 4. The results were positive in all but a few samples, although the concentrations were well below the AEC standards. This nuclide is produced continuously while the reactor is in operation by the action of neutrons on the heavy water used for moderating and cooling. Although the reactor has not been in operation since January 1969, the heavy water containing the long-lived tritium was handled while the reactor was dismantled, and a small quantity evidently did escape from the building. The average concentration this year, 185 pCi/m³, was about 30 percent higher than during 1968. Samples were also collected in the east area, 1,829 meters (2,000 yards) from the reactor, during May. These had an average tritium concentration of 12 pCi/m³, compared to 208 pCi/m³ for samples collected

Table 4. Tritium concentrations near CP–5 reactor, January–June 1969

Month	Number of samples	Concentration (pCi/m³)			Percent of AEC standard	
		Average	Minimum	Maximum	Average	Maximum
January	6	286	130	504	0.14	0.26
February	14	109	14	470	.05	.24
March	9	228	12	710	.11	.36
April	16	122	<10	549	.06	.27
May	15	208	<10	898	.10	.50
June	16	156	23	788	.08	.39
Summary	76	185	<10	898	0.09	0.50

near the reactor during the same period. The concentration in the east area samples ranged from less than 10 to 21 pCi/m³, and was greater than 10 pCi/m³ only on days when the concentration near the reactor was more than 100 pCi/m³. The highest value, 21 pCi/m³, was obtained on the day when the concentration near the reactor was also a maximum, 898 pCi/m³. The correlation is sufficiently good to conclude that the positive results in the east area samples were real and the result of tritium from the CP-5 reactor.

Water monitoring

Argonne wastewater is discharged into Sawmill Creek, a small stream that runs through the Argonne grounds and enters the Des Plaines River about 500 yards downstream from the wastewater discharge. Sawmill Creek was sampled upstream from the Argonne site and downstream from the wastewater outfall to determine if radioactivity was added to the stream from Argonne wastewater. The sampling locations are shown in figure 2.

Below the wastewater outfall the creek was usually sampled three times weekly except when five continuous sequential samples were collected for 5 weeks. Since it was impractical to analyze all the samples for all the radionuclides and elements desired, equal portions of the individual samples collected each week were combined and analyzed. The results obtained in this way represent the average concentrations in the weekly samples. Above the site, samples were collected twice monthly and at least one sample each month was analyzed for each radionuclide of interest. The total alpha and beta radioactivities found in Sawmill Creek during January–June 1969 are given in table 5. Upstream from the Argonne site, the alpha activity was due primarily to radioactive nuclides that occur naturally in the stream and was in the normal range. Any additional radioactivity downstream was due to alpha-emitting nuclides in the wastewater. The concentration of alpha radioactivity in the creek resulting from the presence of Argonne wastewater can be estimated as follows.

The ratio of creek water to Argonne wastewater ranged from about 1 to 10 during the first half of 1969. This increased dilution above previous years is due to the discharge into the creek of water from a new public sewage disposal plant north of the laboratory. Consequently, the natural alpha radioactivity in the creek below the outfall varied from 50 to 90 percent of the upstream concentration and the alpha radioactivity (primarily uranium) added by Argonne wastewater varied from 0.9 pCi/liter, when the dilution factor was one, to less than 0.1 pCi/liter when the dilution factor was about ten. Although some alpha radioactivity was added to the creek in Argonne wastewater, the amounts were not large enough to increase the total alpha radioactivity in the steam above the normal range, and on some days the wastewater evidently contained less alpha radioactivity than upstream water.

The alpha-particle emitters most likely to be present in Argonne wastewater are isotopes of uranium, plutonium, and thorium. The alpha

Table 5. Non-volatile alpha and beta radioactivity in Sawmill Creek water, Argonne, January-June 1969

Month	Location[a]	Number of samples	Alpha radioactivity (pCi/liter)			Beta radioactivity (pCi/liter)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
January	Upstream	2	3.4	3.2	3.6	11	11	11
	Downstream	14	2.2	1.5	2.6	12	9.0	16
February	Upstream	2	2.2	1.8	2.5	9.4	8.1	11
	Downstream	14	2.5	2.1	3.1	13	11	16
March	Upstream	2	3.9	3.3	4.5	15	13	17
	Downstream	12	2.9	1.7	3.6	14	10	18
April	Upstream	2	2.0	1.7	2.3	10	10	11
	Downstream	14	2.1	1.9	2.2	9.4	8.7	10
May	Upstream	2	1.9	1.5	2.2	11	8.8	14
	Downstream	25	1.7	1.2	2.5	12	9.5	14
June	Upstream	2	3.4	2.6	4.1	19	7.9	31
	Downstream	14	2.3	1.2	3.6	13	8.7	23
Summary	Upstream	12	2.8	1.5	4.5	13	7.9	31
	Downstream	93	2.3	1.2	3.6	12	8.7	23

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

Table 6. Alpha-emitting elements in Sawmill Creek water, Argonne January–June 1969

Element	Location[a]	Number of samples	Concentration (pCi/liter)			Percent of AEC standard	
			Average	Minimum	Maximum	Average	Maximum
Uranium	Upstream	6	1.7	1.2	2.6	0.004	0.007
	Downstream	40	1.8	.9	2.9	.005	.007
Plutonium	Upstream	6	—	—	<.05	—	<.001
	Downstream	40	—	—	<.05	—	<.001
Thorium	Upstream	6	—	—	<.05	—	<.003
	Downstream	40	—	—	<.05	—	<.003

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

radioactivity in the creek water due to these elements are summarized in table 6.

In addition to the natural beta radioactivity in the creek, beta radioactivity from nuclear detonations was detected at both sampling locations and beta radioactivity from Argonne wastewater was found in some samples below the outfall. The natural beta radioactivity is approximately 5 pCi/liter above the site and 2 to 5 pCi/liter below the site depending on the dilution by wastewater. The Argonne contribution to the total nonvolatile beta radioactivity below the outfall during the first half of 1969 is estimated to be approximately 2 pCi/liter compared to 7 pCi/liter in 1968. The remaining activity at both locations, 5 to 8 pCi/liter, was due to fallout. The concentration of fallout activity was about two-thirds that found during 1968.

The results of analysis of Sawmill Creek water for specific beta-emitting nuclides are summarized in table 7. The principal beta-particle emitter added to the creek by Argonne wastewater was tritium. This radionuclide, present as water (HTO), is not included in the total beta activity in table 5 since the latter radioactivity was determined by evaporating the water and measuring the nonvolatile residue. Separate samples were analyzed specifically for tritium. Although some of the cesium–137, tritium, and strontium–90 were added to the creek by fallout, the total concentration, regardless of source, must be used in assessing the health hazard of a radioactive nuclide

Table 7. Beta-emitters in Sawmill Creek water, Argonne, January–June 1969

Radionuclides	Location[a]	Number of samples	Beta radioactivity (pCi/liter)			Percent of AEC standard	
			Average	Minimum	Maximum	Average	Maximum
Barium-140	Upstream	6	—	—	<2	—	<0.007
	Downstream	48	—	—	<2	—	< .007
Cerium-144	Upstream	12	—	—	<10	—	< .1
	Downstream	93	—	—	<10	—	< .1
Cesium-137	Upstream	6	0.5	<0.5	1.2	0.003	.006
	Downstream	93	.8	< .5	2.3	.004	.012
Cobalt-58	Upstream	12	—	—	< 5	—	< .005
	Downstream	93	—	—	< 5	—	< .005
Cobalt-60	Upstream	12	—	—	< 3	—	< .006
	Downstream	93	—	—	< 3	—	< .006
Tritium	Upstream	6	740	400	1,160	.025	.039
	Downstream	93	7,490	440	69,700	.25	2.3
Iodine-131	Upstream	—	—	—	—	—	—
	Downstream	93	—	—	< 3	—	<1
Strontium-89	Upstream	6	—	—	< 2	—	< .07
	Downstream	48	—	—	< 2	—	< .07
Strontium-90	Upstream	6	1.9	1.1	2.6	.6	.9
	Downstream	48	1.5	< .5	3.1	.5	1.0
Technetium-99	Upstream	6	—	—	< .5	—	< .0002
	Downstream	93	< .5	< .5	1.0	< .0002	.0003
Thorium–protactinium-234	Upstream	6	1.4	1.0	2.1	.007	.011
	Downstream	40	1.4	.7	2.3	.007	.012

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

not naturally present in the environment. The percent of the AEC standard given in the table was calculated on this basis. As indicated in the table, the beta radioactivities in the creek were very low compared to the AEC standards.

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in the latter two streams is important in assessing the contribution of Argonne wastewater to the environmental radioactivity. The Des Plaines River was sampled monthly above the mouth of Sawmill Creek and weekly below the mouth to determine if the radioactivity in the creek had any effect on the radioactivity in the river. The total radioactivity is summarized in table 8, and the results of analysis for specific elements and radionuclides are given in table 9.

Table 8. Average radioactivity in Des Plaines and Illinois River water, ANL, January–June 1969

Location	Concentration (pCi/liter)			
	Non-volatile alpha radio-activity	Uranium	Non-volatile beta radio-activity	Tritium
Des Plaines River[a] (above Sawmill Creek)	3.4	1.9	10	460
Des Plaines River[b] (below Sawmill Creek)	3.0	1.8	12	4,110
Illinois River[c]	3.6	2.8	9	<400

[a] Sampled near Route 45, upstream from the mouth of Sawmill Creek.
[b] Sampled near Lemont, downstream from the mouth of Sawmill Creek.
[c] One sample collected on June 19 at McKinley Woods opposite the Dresden Nuclear Power Plant.

Tritium was the only radionuclide whose concentration was higher below the mouth of Sawmill Creek, and the additional activity at this location evidently originated in Argonne wastewater. However, the average and maximum concentrations below the creek amounted to only 0.13 and 1.1 percent, respectively, of the AEC standards. The concentration of tritium in the river above the creek is similar to that found last year in the Des Plaines River and to that found in other streams in the area. This nuclide occurs naturally and is also present in debris from nuclear tests.

The concentrations of the other radionuclides and of the total alpha and beta radioactivities were in their normal ranges at both locations. The average beta radioactivity decreased by about 25 percent from 1968. The natural nonvolatile beta radioactivity in the river is 5 to 10 pCi/liter, and any excess was due to fallout. The Illinois River was sampled at McKinley Woods on June 19, and the alpha, beta, uranium, and tritium radioactivities (3.6, 9.0, 2.8, and < 400 pCi/liter, respectively) were normal and similar to those found in other streams in the area. No evidence of radioactivity from Argonne was detected.

Radioactivity in milk

Raw milk was collected monthly from a local dairy farm and analyzed for several fission products. Strontium–89, iodine–131, and barium–140

Table 9. Radioactivity in Des Plaines River water, Argonne January–June 1969

Radionuclide	Location[a]	Number of samples	Concentration (pCi/liter)		
			Average	Minimum	Maximum
Barium-140	Upstream	2	—	—	<2
	Downstream	5	—	—	<2
Cerium-144	Upstream	6	—	—	<10
	Downstream	26	—	—	<10
Cobalt-58, -60	Upstream	6	—	—	<10
	Downstream	26	—	—	<10
Tritium	Upstream	3	460	400	830
	Downstream	12	4,110	400	32,400
Plutonium (alpha)	Upstream	3	—	—	<.05
	Downstream	6	—	—	<.05
Strontium-89	Upstream	2	—	—	<2
	Downstream	5	—	—	<2
Strontium-90	Upstream	2	1.9	1.2	2.6
	Downstream	5	1.6	1.2	2.4
Thorium (alpha)	Upstream	3	—	—	<.05
	Downstream	6	—	—	<.05
Thorium–protactinium-234	Upstream	1	—	—	1.5
	Downstream	6	1.4	1.0	1.9
Uranium (alpha)	Upstream	1	—	—	1.9
	Downstream	6	1.8	1.3	2.4

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

were not present in concentrations greater than the minimum detectable amounts of 20 pCi/liter for iodine–131 and 3 pCi/liter for the other two radionuclides. The strontium–90 and cesium–137 concentrations are given in table 10. These two radionuclides are long-lived fission products from past nuclear tests and their presence in milk is not related to Argonne operations. The cesium–137 concentrations during the first half of 1969 decreased to one-half of the 1968 concentrations, while the strontium–90 concentrations were nearly the same.

Table 10. Fission product concentrations in milk January–June 1969

Date collected	Concentrations (pCi/liter)	
	Cesium-137	Strontium-90
January 2	17	6.3
February 5	16	2.1
March 5	16	6.2
April 2	15	5.2
May 8	30	5.2
June 3	12	7.2
Average	18	5.4

Conclusion

Argonne's contribution to the environmental radioactivity was primarily limited to tritium and argon–41 in the air and to tritium in water from Sawmill Creek and the Des Plaines River. The only radioactivity detected off the site was the tritium in the two streams. The concentrations were low and did not constitute a health hazard.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	May 1969
July–December 1968	February 1970

2. S1C Prototype Reactor Facility[3] January–December 1968

Combustion Engineering, Inc.
Windsor, Conn.

The S1C Prototype Reactor Facility is a land-based nuclear submarine power plant operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, Inc. The prototype contains a pressurized water reactor power plant which is used to conduct research and development work and to train personnel in the operation of naval reactor power plants. Reactor power operations at the S1C Prototype Facility began in December 1959.

The low level radioactive waste discharged intermittently from S1C prototype operations consist mainly of water. Small quantities of airborne particulates in gaseous waste are also generated and released on occasion in the ventilation exhaust air.

Essentially, all of the radioactive waste originates from the activation of minute amounts of impurities or corrosion products in the circulating water used as a reactor coolant. All materials released to the environment are routinely monitored to assure that waste disposal operations comply with AEC regulations.

Air monitoring

Ventilation air from the submarine hull and the supporting facility at the prototype site may contain small amounts of radioactive gases or particulates. This ventilation air is discharged to the environment through an exhaust stack. The ventilation air is continuously monitored for radioactivity by automated counters which control the discharge of the exhaust air. When the AEC maximum permissible concentration limits are exceeded, the exhaust air is discharged through a high-efficiency filter bank or the ventilation system is completely shut down and the hull sealed. In addition, air is continuously sampled for particulates at onsite and offsite locations shown in figure 3.

[3] Summarized from "S1C Prototype Reactor Facility Environmental Monitoring, Report for 1968."

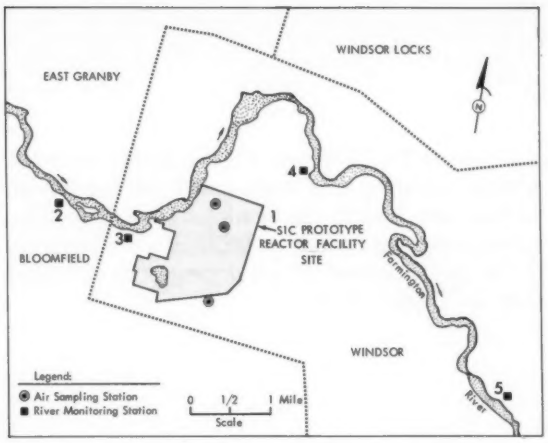

Figure 3. Environmental monitoring locations, S1C prototype site

Liquid radioactive waste

Drainage from all systems which are known to contain radioactive liquids was collected, processed and sampled prior to discharge to the environment to assure that discharge concentrations were within the required limits. In addition, waste effluent is sampled as it is discharged to the environment. These samples are analyzed for radioactivity and the results are retained as part of the permanent records.

The S1C Prototype discharged a total of 1.81 megaliters of radioactive liquid waste containing 511.8 microcuries of radioactivity during 1968 for an annual average discharge concentration of 280 pCi/liter.

Water monitoring

Water and sediment samples from the Farmington River are taken quarterly and analyzed. These samples are used to determine if buildup (reconcentration of radioactivity) is occurring.

The Farmington River was sampled at the outlet of the S1C Prototype discharge brook. During 1968, gross gamma radioactivity of water samples from the outlet of the S1C discharge brook ranged from 24 to 44 pCi/liter which is well below the 30 nCi/liter maximum permissible concentration specified by the Federal Regulations for cobalt–60, the most limiting radionuclide in S1C wastes. In 1967, the techniques used to analyze for radioactivity in water samples were changed from beta-particle to gamma-ray counting. This provides better detection of small changes in radioactivity levels.

Airborne radioactivity

All areas on site where gaseous and/or particulate airborne radioactivity could be present are directed through ducts to monitored stacks. The stacks are monitored for airborne levels on a continuous basis. The facility's operational controls ensure that the radioactive concentration in the environment does not exceed the 100 pCi/m^3 limit. This limit is based on the assumption that levels of strontium–90 and alpha-particle emitting isotopes are insignificant.

The airborne particulate radioactivity samples taken during discharge are recounted 4 hours after discharge. This delay allows short-lived radioactivity to decay. The air effluent analysis records indicate that no significant airborne radioactivity was discharged above natural background levels.

Conclusions

Results of the analyses and of the continuous monitoring throughout 1968 have indicated that S1C Prototype operations have met all of the Federal Regulations pertaining to AEC standards. Environmental analyses indicate that no significant quantities of radioactivity have accumulated above the preoperational environmental results. It is, therefore, concluded that the facility operations have not adversely affected the surroundnig environment.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–December 1967	March 1969

Reported Nuclear Detonations, June 1970

(Includes seismic signals from foreign test areas)

The U.S. Atomic Energy Commission announced only one nuclear test for June 1970. A nuclear test of low-intermediate yield (20–200 kilotons TNT equivalent) was conducted underground on June 26, 1970, by the Atomic Energy Commission at its Nevada Test Site.

On June 27, 1970, the United States recorded seismic signals which originated from the Soviet nuclear test area in the Semiplatinsk region. The signals were equivalent to those of a nuclear test in the low-intermediate yield range (20–200 kilotons TNT equivalent).

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